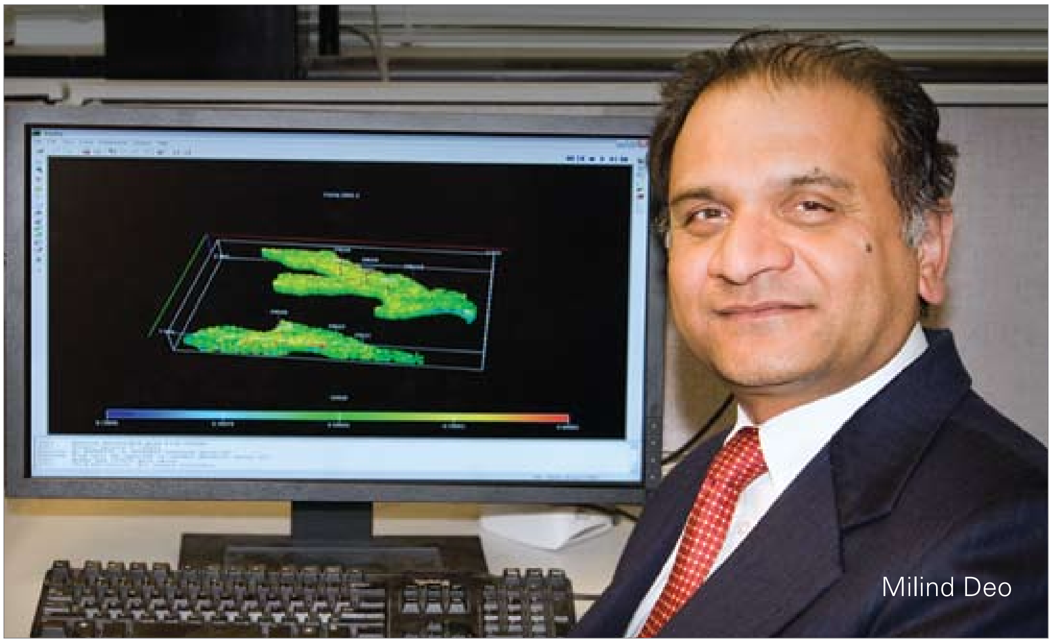
NOVEMBER 2009

UTAH**ENGINEERING**

Inside

THE UNIVERSITY OF UTAH

High-Performance Computing Technology for Enhanced Fuel Recovery



Milind Deo

Fossil fuels, conventional crude oil and gas resources contribute a significant portion of the world's energy needs. In 2008, the United States alone consumed a total of 7.14 billion barrels of oil (refined petroleum products and biofuels), which was about 23% of total world oil consumption for that year, according to the Energy Information Administration.

Despite the move toward alternative fuels as the world becomes more carbon-constrained, the United States will continue to rely on oil and gas to meet its energy needs for the foreseeable future.

"The United States has always been a leader and is at the forefront of oil and gas technologies," says Milind Deo. "No matter which direction we go, oil and gas will continue to play a pivotal role in providing the nation's energy." Deo is a professor of chemical engineering, director of the Petroleum Research Center, and associate dean of academic affairs at the University of Utah College of Engineering. He is also a member of the Institute for Clean and Secure Energy, an interdisciplinary research institute at the University working on various facets of the energy problem.

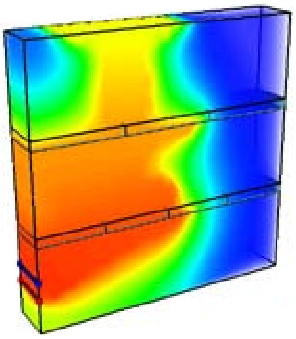
Deo's research involves maximizing production from oil reservoirs in an economical way. He is also seeking to explore the use of unconventional petroleum resources for fuel production, such as oil shale, oil sands, and unconventional gas reservoirs (tight gas and coal-bed methane). >>

The Process of Oil Production

The extent of an oil or gas reservoir and its quality are determined by a variety of tools such as seismic mapping and interpretation, well logging, etc. Laboratory testing can determine the gas evolution and changes in volume as oil is brought from high pressure in the reservoir to surface conditions. Studying how easily fluids flow through the rock helps determine what proportion of the oil can be produced.

When an oil well is first drilled, fluid is likely under pressure and flows toward the well. The process of extracting the flowing oil is referred to as *primary production*. However, well pressure falls as oil is recovered, and at some point the oil rate declines below the economic limit. To push out remaining oil, a number of methods involving *secondary production* are employed, such as injecting water, natural gas, or carbon dioxide into the well.

"There is an amount of oil that you can't get out with primary and secondary production," says Deo. "About 30% could be left behind."



The figure shows a computer simulation of a process called Steam Assisted Gravity Drainage (SAGD) used primarily for the production of heavy oil from Canadian oil sands. Minimizing the amount of energy used in producing oil, maximizing recovery, and finding other efficient means to drain the oil are some aspects that can be examined using the computer simulators developed by Deo's group.

High-Performance Computing

Deo is developing computer simulation models to understand characteristics of complex petroleum reservoirs that affect oil production, such as rock formation, chemistry of fluids (ranging from condensates to heavy oils that affect oil flow), and the presence of fractures and faults (breaks or ruptures that cause divisions in rock formations). Reservoirs are not uniform. They have variable porosities and permeabilities, and may be broken up with fractures and faults that affect the flow of fluid. Deo says understanding these features is important because they are found in reservoirs ranging from unconventional gas and fuels to conventional oil and gas production.

Various computer models developed by Deo's group are used to understand reservoir characteristics. His research could aid in better recovery of oil and natural gas. For example, the models may be used to identify and prevent premature water breakthrough, determine optimal methods of producing from low-permeability natural gas reservoirs, or design heat introduction methods in fractured heavy oil systems.

"We need to optimize production from our resources," says Deo. "As we perform computer simulations and understand the behavior of each reservoir, we will know how and where to drill and inject to ensure efficiency and optimum production. This will help us be more energy self-sufficient."

Nuclear Engineering at the U

An expert in computational modeling and theoretical analysis applied to nuclear engineering, Tatjana Jevremovic is helping to build nuclear engineering at the University of Utah. She is the new director of the University of Utah Nuclear Engineering Program (UNEP) and was appointed the Energy*Solutions* Presidential Endowed Chair Professor in Nuclear Engineering, through a generous gift from the Energy*Solutions* Foundation. She is also a professor of chemical engineering and of civil and environmental engineering.

As director of UNEP, Jevremovic is helping to establish new courses and a new minor in nuclear engineering. Traditionally, the U of U has offered only graduate degrees in nuclear engineering. Jevremovic is also concerned with helping students understand abstract concepts. "We are developing experiential interactive learning tools on the Web to help students visualize the physics phenomena that occur in a nuclear reactor," she says.

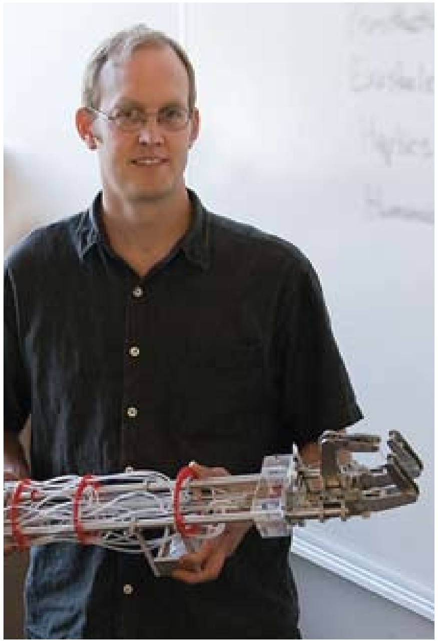
Jevremovic's research focuses on developing advanced computational simulation tools and methodologies for faster nuclear reactor simulations. Her research is applied to such areas as medicine, homeland security, and space exploration.

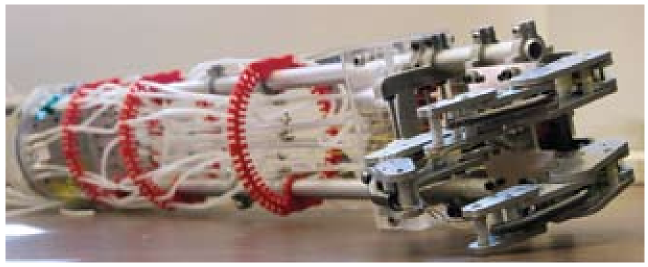
One project involves radiation therapy for breast cancer. She is simulating using a neutron beam from a nuclear reactor to irradiate cancer cells treated with drugs. Jevremovic hopes that computational simulations will help determine the optimal approach. She is also developing new radiation treatment tools.

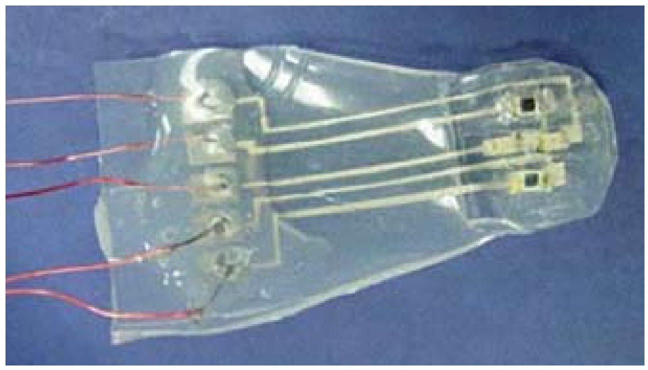
In the area of national security, Jevremovic is developing computational software to detect nuclear materials. She is focused on creating tools to screen the nine million ships that carry cargo into the United States every year. "It is impossible to open each shipment," she says. "We need an easier way to detect dangerous nuclear materials." Jevremovic is working on the project with Rapiscan Systems, a global company that specializes in cargo screening and metal detectors.

Biology and Robotics

DEVELOPING WEARABLE FINGERNAIL SENSORS AND EXOSKELETONS







LEFT: Stephen Mascaro holds a mechanical robotic arm with shape-memory alloy "muscles," which may lead to development of robotic exoskeletons for individuals who have lost muscle use.

TOP RIGHT: The robotic arm.

BOTTOM RIGHT: A closeup of a fingernail sensor that measures finger movement, potentially allowing for the development of virtual computer keyboards and mouses.

Stephen Mascaro is developing sensors that can detect blood flow patterns in the human fingertip. These fingernail sensors may one day be used to operate computers in a novel and ergonomic way. An assistant professor in the Department of Mechanical Engineering, Mascaro also directs the University of Utah Biorobotics Laboratory.

Fitted onto a person's fingernails, the sensor devices project light into the fingernails to measure blood volume through color change. As a finger presses down or slides along a surface, the fingernail's color patterns change. Mascaro's sensors detect those patterns and accurately measure movement, direction and force. The technology may allow for the development of virtual computer keyboards and mouses. Wearing the sensors, a person would apply only slight pressure with their fingers to a hard surface to make letters appear or a cursor move on a computer screen. Such research may be invaluable to people with carpal tunnel syndrome or other repetitive-motion injuries.

"The slightest touch changes fingernail coloration, so a person wouldn't have to push very hard," he says. "And you could touch anywhere—on your desktop or on your screen."

The rubber sensors are patterned with thin films of metal and implanted with light-emitting diodes that shine light into a fingertip. Pockets of liquid metal are added to allow outside connections to instrumentation that measures signals. Mascaro and his associates are using a magnetic levitation device to aid in calibrating the device to each individual. "We're trying to perfect the process of making sensors that will universally work on different finger shapes and sizes," says Mascaro.

Other research in Mascaro's lab involves making wearable robotic exoskeletons to help individuals who have lost muscle use and control. The robotic "muscles" in the exoskeleton are made from shape-memory titanium alloy wires that contract when heated and expand to their original shape when cooled—similar to how human muscles flex and relax.

Individually encased in rubber tubes, each shape-memory wire—only a fraction of a millimeter in diameter—is heated and cooled alternately with hot and cold water running through the tube. Several strands of wires make up one robotic muscle. "The wires contract only about 4 percent of their length, which is 20 percent of what a human muscle can do," says Mascaro. "On the other hand, they exert about 200 times the force of a human muscle for the same size. And we can leverage that power with gears or pulleys to achieve the same amount of movement as a human limb."

Powering the muscles with electricity is inefficient, so Mascaro is designing a robotic heart that will alternately pump hot and cold water to the wires. The heart is also being designed with shape-memory wires, so that the chambers of the heart can self-sufficiently contract and extend to circulate fluid throughout the exoskeleton (similar to how a human heart pumps blood to the extremities). "Right now, our robotic heart is only pumping enough fluid to keep itself going and nothing more," says Mascaro. "So our research involves getting more output from it."

Special Matching Scholarship Drive

Over the past 10 years, the College has made significant progress in modernizing and expanding the engineering campus. Investments in new buildings, teaching equipment and student laboratories have created a modern physical environment. This year, we are making a special effort to reach out to students. Deep funding cuts are driving up tuition at a time when family budgets are maximally stressed. Through scholarships, loans and other forms of assistance, the College of Engineering is trying to ease this burden so students can focus on completing their education.

University statistics show that 89 percent of seniors are working at least 20 hours or more, while 31 percent are working 31 hours or more. Scholarships allow students to work fewer hours, become more deeply engaged in academic life, and complete their degrees in the normal time with less debt.

For the next 12 months, the College of Engineering has a special opportunity to match new scholarship gifts of $1,000 and above with an additional $1,000 (for the first 65 donors.) These awards may be named for the donor or someone the donor wishes to honor. The goal of this special appeal is to increase the number of scholarships in this time of economic hardship. This is a great opportunity to leverage your scholarship gift with a significant match.

For information on the matching scholarship drive, please contact: Marilyn Davies, director of engineering development, at mdavies@coe.utah.edu, or (801) 581-7194.

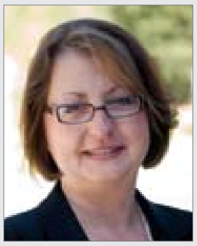
NEW FACULTY HIRES

Otakuye Conroy
Civil & Environmental Engineering

EDUCATION:
Ph.D., environmental engineering, University of Arizona

PREVIOUS POSITION:
Research fellow, Climate and Energy, National Congress of American Indians

RESEARCH INTERESTS:
Organic micro-pollutants and removal during wastewater treatment, soil-aquifer treatment, and riverbank filtration; endocrine disrupting chemibioassays



Tatjana Jevremovic
Nuclear Engineering
Civil & Environmental Engineering
Chemical Engineering

EDUCATION:
Ph.D., nuclear engineering, University of Tokyo

PREVIOUS POSITION:
Associate professor of nuclear engineering, Purdue University

RESEARCH INTERESTS:
Computational methodologies for current and future generation nuclear applications

Faisal H. Khan
Electrical & Computer Engineering

EDUCATION:
Ph.D., electrical engineering, University of Tennessee

PREVIOUS POSITION:
Senior power electronics engineer, Electric Power Research Institute in Tennessee

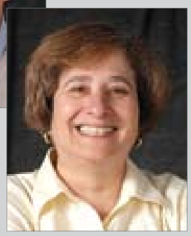
RESEARCH INTERESTS:
DC-DC converters, multilevel converters, hybrid and fuel cell vehicle power management, and energy management of renewable sources

Hanseup Kim
Electrical & Computer Engineering

EDUCATION:
Ph.D., electrical engineering, University of Michigan

PREVIOUS POSITION:
Visiting scholar, Solid State Electronics Laboratory, University of Michigan

RESEARCH INTERESTS:
Bio nano- and micro-systems in moving fluids; system integration; robots; and energy harvesting

PIERRE BÉZIER AWARD

Professors Richard Riesenfeld and Elaine Cohen in the School of Computing won the 2009 Pierre Bézier Award for Solid, Geometric and Physical Modeling and Applications for their sustained leadership, research contributions and teaching in freeform geometric modeling. Cohen and Riesenfeld developed an academic program and coauthored a significant reference and text for advanced study of B-spline methods in computer aided geometric design. The Solid Modeling Association established the award in honor of Pierre Bézier, one of the founders of the field of solid, geometric and physical modeling.

GOEL AWARDED PROFESSORSHIP AND NSF FUNDING

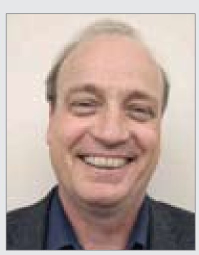
Ramesh Goel, assistant professor of civil and environmental engineering, was awarded an Indo-U.S. professorship to India by the American Society of Microbiology. Under the professorship, Dr. Goel will visit India to conduct a six-day long teaching and laboratory workshop on microbes and sustainability. Goel also received funding from the National Science Foundation to conduct an international workshop on water quality issues and water borne infectious diseases at the Indian Institute of Science, India, in January 2010.

Gianluca Lazzi
Electrical & Computer Engineering

EDUCATION:
Dr.Eng., electronic engineering, Sapienza University of Rome; Ph.D., electrical engineering, University of Utah

PREVIOUS POSITION:
Professor of electrical and computer engineering, North Carolina State University

RESEARCH INTERESTS:
Bioelectronics engineering; implantable devices; biological effects and applications of electromagnetic fields; wireless electromagnetics and antennas; and computational electromagnetics

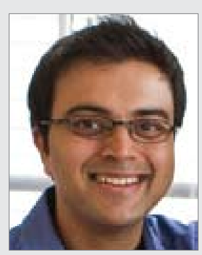


John McLennan
Chemical Engineering

EDUCATION:
Ph.D., civil engineering (rock mechanics), University of Toronto

PREVIOUS POSITION:
Instructional research staff, Energy and Geoscience Institute, University of Utah

RESEARCH INTERESTS:
Gas storage mechanisms in resource plays, stimulating low permeability reservoirs, carbon dioxide enhanced oil recovery, enhanced geothermal systems

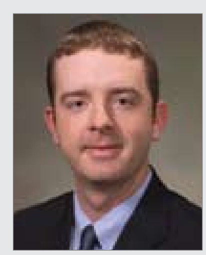


Rajesh Menon
Electrical & Computer Engineering

EDUCATION:
Ph.D., electrical engineering & computer science, MIT

PREVIOUS POSITION:
Research Laboratory of Electronics, MIT

RESEARCH INTERESTS:
Nanopatterning, nanofabrication, optical nanoscopy, micro-and nano-optics, solar concentrators, and plasmonics



Richard J. Porter
Civil & Environmental Engineering

EDUCATION:
Ph.D., Civil Engineering, Pennsylvania State University

PREVIOUS POSITION:
Assistant research scientist, Texas Transportation Institute, Texas A&M University

RESEARCH INTERESTS:
Study and modeling of driver behavior and decision-making for highway safety and traffic operations

Darrin J. Young
Electrical & Computer Engineering

EDUCATION:
Ph.D., electrical engineering and computer sciences, UC-Berkeley

PREVIOUS POSITION:
Associate professor of electrical engineering and computer science, Case Western Reserve University

RESEARCH INTERESTS:
MEMS design, fabrication, and integrated circuits design for wireless sensing, biomedical implant, RF and optical communication, and industrial applications

HARRIETT V. RIGAS AWARD

Cynthia Furse, professor of electrical and computer engineering, received the 2009 Harriett V. Rigas Award from the Institute of Electrical and Electronics Engineers. Furse, who was recently appointed associate vice president for research at the U of U, is being honored for excellence in teaching, the development of educational technology that enhances student learning, and actively encouraging participation of women in electrical and computer engineering. She was also recently recognized at the Women Tech Awards in Salt Lake City, which acknowledges technology-focused women who are driving innovation, leading technology companies, and contributing to the community.

CYBER PIONEER AWARD

Professor Chris Johnson, director and founder of the Scientific Computing and Imaging (SCI) Institute, was the 2009 recipient of the Cyber Pioneer Award from the Utah State Bar's Cyberlaw Section. Earlier this year, Johnson made a presentation at the Library of Congress about how computing imaging has changed the face of medicine. His research interests focus on scientific computing, with emphasis on inverse and imaging problems, adaptive methods, problem solving environments, numerical analysis, biomedical computing, and scientific visualization.

ARCS CHAPTER AT THE U

A national volunteer women's foundation called Achievement Rewards for College Scientists (ARCS) recently established an ARCS Chapter at the University of Utah. ARCS's mission is to provide scholarships to top U.S. graduate students in science, medicine and engineering. The Utah Chapter will become the 15th to join ARCS, which has 1,500 members in 11 other states. Dr. Cecelia Foxley, former Utah commissioner of higher education, will serve as the ARCS-Utah Chapter president. Since it was established in 1957, ARCS has granted more than 13,000 scholarships worth $66 million to 7,700 students.

Technology Commercialization at the U

CFM printer

Closeup of two CFM printheads

Engineering Iditarod

Engineering students and alumni built sleds and raced in the College of Engineering's first Engineering Iditarod competition. About 17 teams participated in the contest to see who could find the most hidden textbooks to be redeemed for prizes, including campus bookstore scholarships. The College of Engineering hosted the contest to build community among approximately 80 students and alumni from the College's seven engineering departments.

TOOL FOR DRUG DISCOVERY AND CLINICAL DIAGNOSTICS

PHOTO CREDIT: Wasatch Microfluidics

Wasatch Microfluidics, a University of Utah startup company, is developing microfluidic technologies for biological sample processing, microarray printing, high-sensitivity drug discovery assays, and high-throughput diagnostics. The company produces the Continuous Flow Microspotter (CFM), a device that prints proteins onto microarrays (glass slides used in medical analysis and drug development) more uniformly than other technologies.

Launched in 2004, the company is now developing a microfluidic flow cell array that combines CFM technology with a surface plasmon resonance (SPR) device that measures the amount of material the CFM deposits onto a microarray. The combined device can perform dozens more tests at a time than typical SPR instruments. The goal of the microfluidic flow cell array is to help drug companies work faster in discovering drugs to treat diseases such as cancer, HIV, and diabetes, among others.

The CFM was developed at the U of U by company founder Bruce Gale, associate professor of mechanical engineering, in conjunction with David Myszka, a researcher in biochemistry at the U, and Josh Eckman, a former U student who graduated with an M.S. in mechanical engineering. Wasatch Microfluidics was launched after the CFM took first place in the Utah Entrepreneur Challenge, a statewide business plan competition.

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ALUMNI

Warnock Awarded

NATIONAL MEDAL OF TECHNOLOGY AND INNOVATION

John Warnock, a University of Utah alumnus from the Department of Electrical and Computer Engineering and a pioneer of the information age, has been named by President Barack Obama to receive the National Medal of Technology and Innovation—one of the highest honors bestowed by the United States government on scientists, engineers, and inventors. Warnock received the honor along with his Adobe Systems Co-founder Charles Geschke and four other recipients in a White House ceremony in October 2009. Other award recipients at the ceremony received the National Medal of Science.

Warnock was given the award for his "outstanding contributions to the promotion of technology for the improvement of the economic, environmental, or social well-being of the United States," according to a White House press release.

"These scientists, engineers and inventors are national icons, embodying the very best of American ingenuity and inspiring a new generation of thinkers and innovators," Obama said of the recipients. "Their extraordinary achievements strengthen our nation every day—not just intellectually and technologically but also economically, by helping create new industries and opportunities that others before them could never have imagined."

PHOTO CREDIT: Associated Press

Warnock pioneered the development of world-renowned graphics, publishing, and Web and electronic document technologies that have revolutionized the field of publishing and visual communication. He was previously president and then chairman and CEO of Adobe. He is currently co-chairman of the Board of Directors of Adobe. Earlier this year, Warnock was elected to the American Philosophical Society in the Mathematical and Physical Sciences class.

Warnock and his wife, Marva, provided the cornerstone gift for the John and Marva Warnock Engineering Building at the University of Utah, along with three Presidential Endowed Chairs. Warnock holds B.S. and M.S. degrees in Mathematics and a Ph.D. in Electrical Engineering, all from the University of Utah. Marva holds a B.S. in sociology from the University of Utah.